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Title of the thesis: “Integrated Magnetics based DC-DC converter topologies for a DC Micro-grid.”

SYNOPSIS

In the present day, owing to the increasing number of electronic loads such as computer power supplies, Compact fluorescent lamps (CFL) and the increasing number of sources such as solar photovoltaics, fuel cells (DC sources), DC Micro-grids provide a more efficient solution compared to the AC counterpart in terms of the number of stages involved in conversion. Also, the ability to be readily buffered to storage elements is an advantage in a DC system. Apart from this, there are no issues of frequency stability, reactive power transfer and ac power losses.
A DC micro-grid is effectively a multi-port dc-dc converter. The ports refer to the various sources and loads that are part of the micro-grid. Sources could be unidirectional (as in the case of PV, load) or bidirectional (as in the case of batteries). Interfacing a variety of ports and controlling power flow between these ports presents an interesting challenge.

Commonly used topologies interface the various ports at the DC bus capacitor thereby making the DC bus capacitor bulky. Apart from this, the DC bus coupled topologies route power from one port to another via the central capacitor. This increases the number of stages in transferring power from one port to another. An alternative topology is to use the active bridge type converters where dynamic power flow equations are required to control inter-port power flow. But, as the number of stages increase, the computations get tedious.In this thesis, a novel topology is proposed that uses a UU type transformer core to interface all the power ports. This alleviates the problems faced in the DC bus coupled topologies. A PWM scheme to control simultaneous power flow from each of the ports is also proposed in this thesis. The PWM scheme enables the usage of simple constant frequency average current mode control to dynamically control power sharing ratio between the various ports delivering to loads. By means of the proposed PWM scheme and the control scheme, the drawbacks of the active bridge topologies are alleviated. Using the proposed topology and the PWM scheme, a prototype micro-grid system is developed for a system comprising of the utility grid, batteries, solar PVs and resistive loads. Yet another aspect of the thesis explores the concept of connecting multiple micro-grids in order to create a 'local power network'. A potential application for this could be in interconnecting residential buildings and routing power from one house to another in order to balance demand and supply among these houses. This is against the growing trend of using the utility grid to also sink power and subsequently route it to other houses connected to the grid. Unfortunately not all areas have access to the utility grid. Additionally, turning the grid bidirectional requires that a number of standards be met and policies be created. But, the standard for using a local network that only involves a unidirectional grid is fixed by the community that owns such a network. In a crude sense, this scenario can be compared to the existence of a local area network to transfer information among users of the network. In this thesis, a prototype local power network interconnecting two micro-grids has been implemented.